RESEARCH DEPARTMENT

A subjective investigation into preferred microphone balances

RESEARCH REPORT No. B-090

UDC 534.861 1966/25

THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

RESEARCH DEPARTMENT

A SUBJECTIVE INVESTIGATION INTO PREFERRED MICROPHONE BALANCES

Research Report No. B-090
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SUMMARY

This report describes two series of subjective investigations in which members of the public and BBC staff were invited to assess the relative merits of different microphone balance conditions.

It is shown that concert-going members of the public are able to make such assessments with remarkable consistency and that they prefer the sound obtained from a single distant microphone rather than that of a reinforced balance.

1. INTRODUCTION

It is some fourteen years ago since a subjective investigation was undertaken to determine the kind of microphone balance preferred by the public. Since that time the technique of microphone balance for gramophone recordings has changed somewhat, and modern recordings generally use multi-microphone techniques. This has influenced microphone balance techniques for broadcasting, since it has been tacitly assumed that the musical public is thereby conditioned to prefer such balances.

Section 2 describes a pilot investigation which was undertaken some three years ago to determine the ability and reliability of subjects in assessing the relative merits of different microphone balances. The techniques used are discussed, together with results obtained in the pilot investigation.

The work was carried out with the close co-operation of representatives of Central Programme Operations and Sound Broadcasting Engineering Departments who were present throughout the recording sessions and gave valuable assistance with the technical arrangements.

The results of the preliminary investigation were discussed with the Director of Sound Broadcasting, the Head of Central Programme Operations and Chief Assistant, Music Programmes and it was agreed that further investigations should be undertaken using orchestral music of different textures. Arrangements were therefore made to record several excerpts of music during two successive Sunday afternoon transmissions from Maida Vale Studio 1. The final investigation involving 98 subjects and using the methods described in Section 2.2 is described in Section 3.

2. EXPERIMENTAL PROCEDURE

2.1. Preliminary Investigation

This investigation, in which subjects are asked to assess the rank order of several microphone balances is of a purely subjective type, as the phenomena for assessment have no measurable physical dimensions. Thus all individual assessments must be considered correct, unlike an experiment in which subjects are asked, for example, to rank a group of individuals in order of height. In the latter case some of the answers may be demonstrably wrong because the heights of individuals can be measured, but one cannot assess quantitatively the merits of different microphone balances, nor classify answers as right or wrong.

Bearing the above in mind, it was thought that the method of paired comparisons would be most suitable for this investigation.

2.2. Paired Comparisons

In the method of paired comparisons[1] the subjects are presented successively with all possible pairs of objects or conditions and are asked to state a preference for one in each of the pairs. For n objects the number of pairs is $n!/2!(n\text{-}2)!$ which is written as $\binom{n}{2}$. Suppose that there are five conditions A, B, C, D and E, then a preference of A to B can be expressed as A → B. All the ten preferences expressed can be shown in a pentagon of preference as in Fig. 1 and the rank order is obtained from the pentagon by counting the arrows leaving each corner. In Fig. 1 the ranking is A, B, C, D, E.

Suppose on the other hand that the subject had expressed preferences as in Fig. 2.

In this figure the triangle A, C, D is termed a circular triad since A is preferred to C, C is preferred to D, and D is preferred to A. If the heights of individuals were being ranked this would be an error since A cannot be taller than C and C taller than D without A being also taller than D. The interpretation is probably that the subject assessed the pairs from different standards of reference. For instance, (AC), (CD) may have been assessed on the relative balance of woodwind and strings, while (DA) may have been assessed on string tone alone; the ensuing circular triad ACD may therefore be a perfectly valid result and is not necessarily an inconsistency. In ordinary ranking problems dealing with objective comparisons a necessary and sufficient condition for the possibility of expressing the preference as a rank order is that no circular triads shall be present[2]. On the other hand, for this highly subjective experiment a subject was regarded as "consistent" provided he had no more than one circular triad in comparisons between five different conditions.

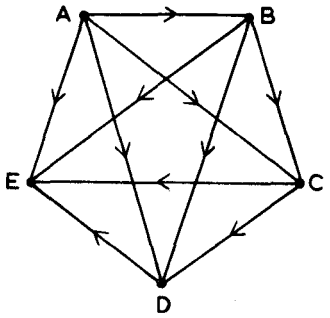

Fig. 1 - Pentagon of preference for a consistent set of answers

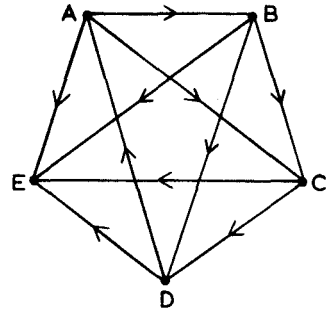

Fig. 2 - Pentagon of preference illustrating one circular triad

Fig. 3 - Photograph of Maida Vale Studio 1 showing the microphone positions used in the pilot experiment

Simultaneous recordings of five different microphone balance conditions were made during a transmission of a short passage from the slow movement of Beethoven's Third Symphony. From these recordings a twin-track test tape was prepared in which each of the five balance conditions was compared with every other balance condition. Thus there were ten pairs of comparisons. The order of recording of the ten pairs of comparisons was so arranged that each condition appeared on each track the same number of times. The test tape was replayed to the subjects and the loudspeaker was switched, at intervals of 10 seconds, between the two tracks. An illuminated indicator panel showed which track was being replayed at any instant. The subjects were required to state which of the two tracks gave the most realistic, or natural, sound in each of the ten pairs of comparisons. The same passage of music was used for each of the ten tests.

2.3. Microphone Balance Conditions in the Preliminary Experiment

Fig. 3 is a photograph of the disposition of microphones in the studio. The five microphone balance conditions were as follows:

(A) A moderately distant single microphone at a height of some 8 m situated at a horizontal distance of 9 m from the rostrum (microphone 1 in Fig. 3).

(B) A more distant single microphone 4·3 m high (microphone 2 in Fig. 3).

(C) The reinforced balance transmitted, which consisted of a main microphone 5·5 m above the conductor's head (3 in Fig. 3), plus separate reinforcement of the woodwind and of the low strings (microphones 4 and 5 respectively in Fig. 3).

(D) A separate feed from the main microphone in condition C (3 in Fig. 3).

(E) A single microphone 3·6 m above the conductor's head (6 in Fig. 3).

2.4. Results of the Preliminary Experiment

The test tape was first replayed to two groups of experienced technical listeners, engineers and Studio Managers respectively, and the results were analysed. Of the fifteen subjects in one group only six of the pentagons of preference had fewer than two circular triads. The answers were analysed in three different ways. The first method is given in Fig. 4, in which the number of subjects ranking a given condition at, or above, the indicated rank is plotted against the rank for each of the five conditions. The area under each of the curves is then a measure of the degree of preference, and absence of intersections of one curve with another may be regarded as indication of clear preference for the higher over the lower. Reference to Fig. 4 shows that the five curves lie close together and intersect, indicating that, taken as a group, the fifteen subjects did not share a definite preference for any one balance.

The second method of analysis was to draw the pentagon of preference for the combined answers given by all subjects for each of the ten comparisons. This pentagon is shown in Fig. 5 from which it can be seen that the group gives one circular triad (ABC).

The third method of analysis was by normal ranking methods[3] the results of which are given in Table 1. Each figure in the table represents the number of times the condition indicated at the left of the row was judged better than that at the top of the column.

TABLE 1

	A	C	B	D	E	Total	
A	-	10	7	12	9	38	1
C	5	-	8½	7	9	29½	2
B	8	6½	-	6½	8	29	3
D	3	8	8½	-	8	27½	4
E	6	6	7	7	-	26	5

It will be noticed in Table 1 that the preference totals expressed for each of the five conditions do not differ greatly. This suggests that the subjects had no common preference for any condition.

The orders of preference for the group obtained by the three methods of analysis are shown in Table 2.

TABLE 2

Preference order	1st	2nd	3rd	4th	5th
Ranking (Table 1)	A	C	B	D	E
Graphical (Fig. 4)	A	C	B	D	E
Group pentagon (Fig. 5)	A,D		B,C		E

Conditions B and D are opposite extremes, one being a very close, and the other a very distant microphone. From Table 1 it is seen that nearly equal numbers of votes were cast for each of these conditions. At this stage the subjects were asked how frequently they attended live orchestral concerts, and with two exceptions the average atten-

dance was one concert in fifteen months. (One subject had last attended a concert in the Queens Hall, which was destroyed by enemy action in 1940). It was concluded that the subjects in this group could well have selected the balance condition which approximated most closely to the sound produced by their own sound reproducing equipment.

A second group of fourteen experienced listeners consisted of members of the BBC staff who are accustomed to monitoring the sound of orchestral music. In this group only one subject gave answers with less than two circular triads. The answers obtained from this group were again analysed in the three ways discussed above, and the results are given in Figs. 6 and 7 and in Table 3.

TABLE 3

	C	D	A	E	B	Total Preferences
C	-	5½	4½	13	11½	34½
D	8½	-	6	8	11	33½
A	9½	8	-	7½	7	32
E	1	6	6½	-	9½	23
B	2½	3	7	4½	-	17

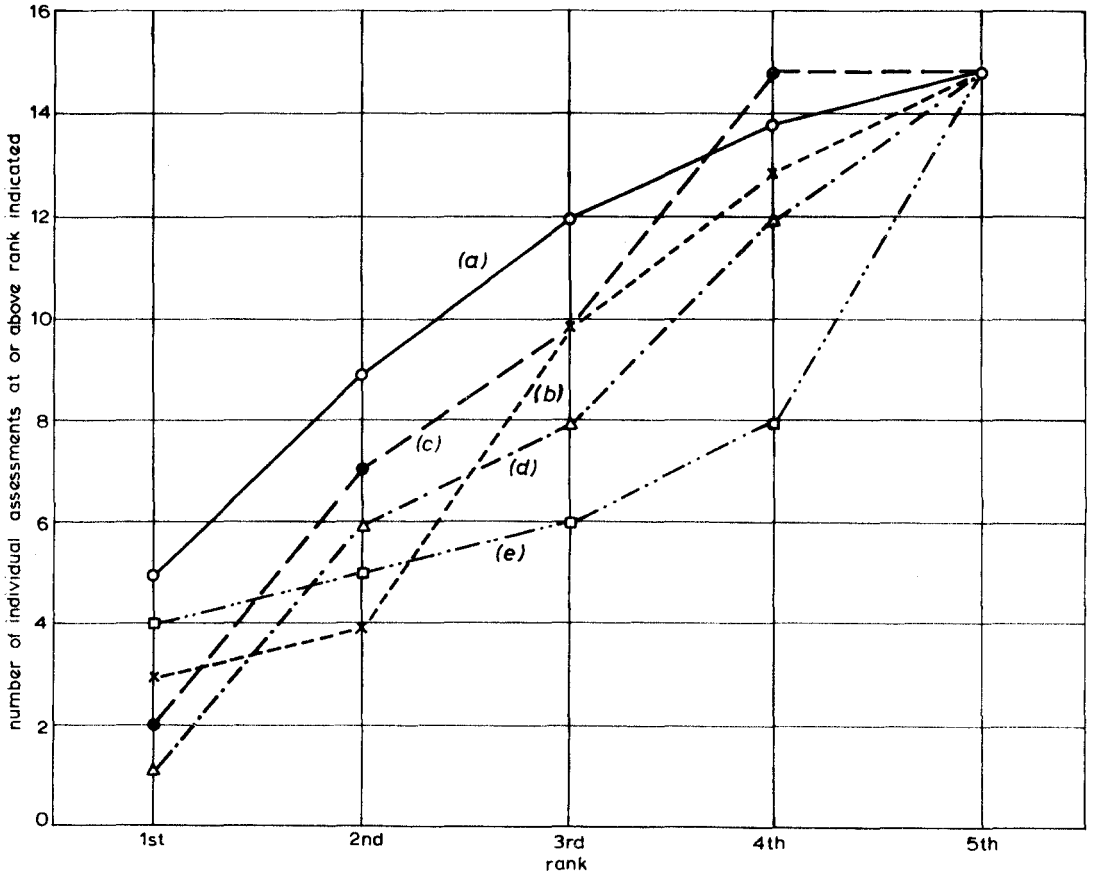

Fig. 4 - Graphical analysis of the results for 15 technical subjects
(*a*) Condition A (*b*) Condition B (*c*) Condition C
(*d*) Condition D (*e*) Condition E

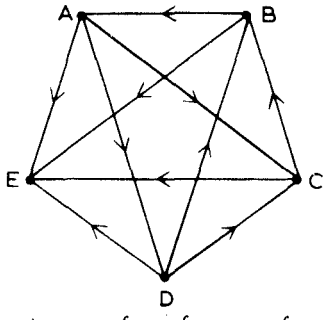

Fig. 5 - Pentagon of preference for 15 technical subjects

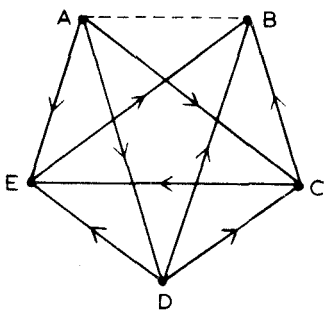

Fig. 6 - Pentagon of preference for 14 operational subjects

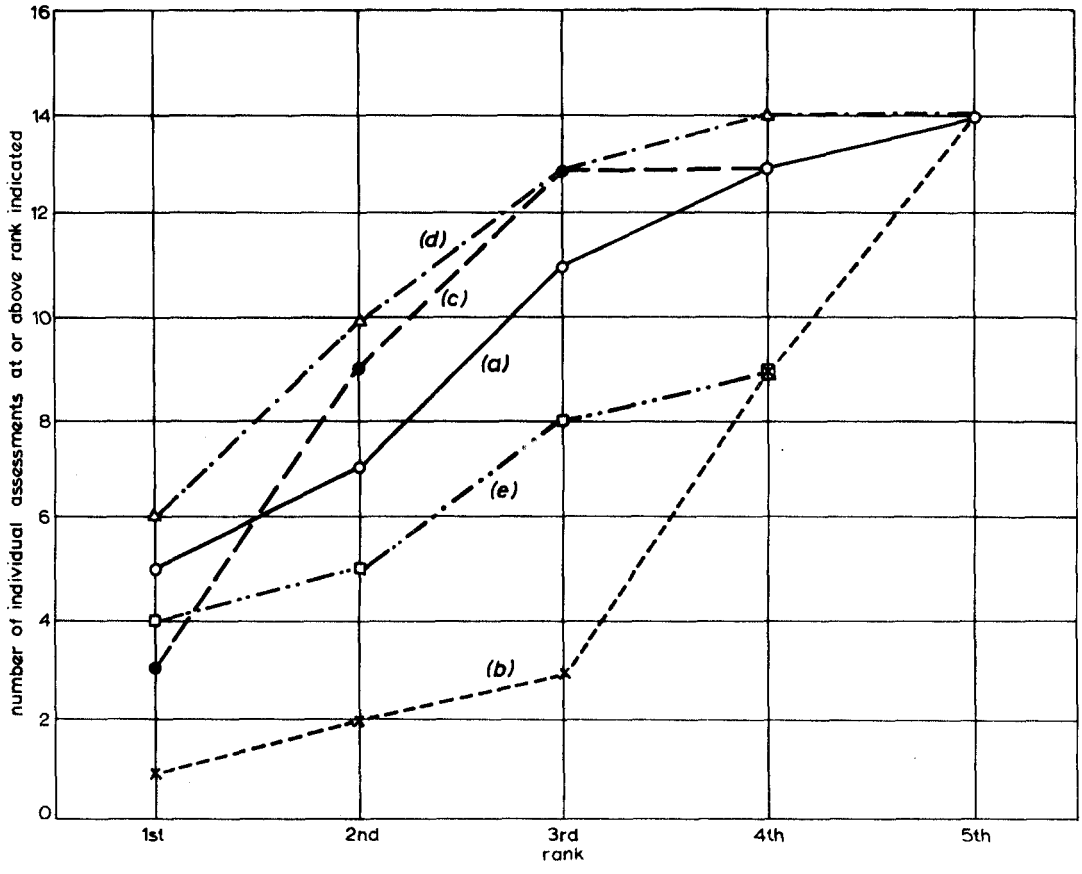

Fig. 7 - Graphical analysis for 14 operational subjects
(*a*) Condition A (*b*) Condition B (*c*) Condition C
(*d*) Condition D (*e*) Condition E

Table 4 shows the orders of preference expressed by this group obtained by the three methods of analysis.

TABLE 4

Preference order	1	2	3	4	5
By ranking method	C	D	A	E	B
Graphical (Fig. 7)	D	C	A	E	B
From group pentagon	A	D	C	E	B

It will be noted from the Total Preferences column in Table 3 that the ranking is again very close. From Table 4 it can be seen that the three methods of analysis gave three different orders of preference. The fact that 13 out of 14 subjects gave answers with two or more circular triads suggests that the individuals in this group of subjects changed their reference standards during the test. It seems that these subjects, while able to assess critically the technical quality of programmes, had no common preference for any one balance condition.

In order to extend the investigation, it was decided that a group of concert going members of the public should be included. These subjects were mostly amateur musicians who were familiar with the sound of live orchestras in different auditoria. A total of 40 subjects participated in the experiment and 23 of them gave answers with no more than one circular triad. The 40 sets of answers were analysed and the results are given in Figs. 8 and 9 and in Table 5.

TABLE 5

	A	D	B	C	E	Total Preferences
A	-	27	20	28	35	110
D	13	-	24½	23½	34½	95½
B	20	15½	-	23	30½	88
C	12	16½	17	-	29	70½
E	5	5½	9½	11	-	31

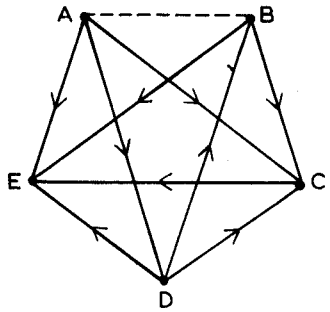

Fig. 8 - Pentagon of preference for 40 concert-going members of the public. Rank order: A, D, B, C, E.

It can be seen from the column of total votes in Table 5 that the members of this group were able to differentiate between the different balance conditions, and it should be noted that all three methods of analysis gave the same preference order, that is A, D, B, C, E.

Appendix I gives tests of significance for the three groups of subjects so far, and shows that the only statistically significant results were those obtained from the group of forty concert goers.

2.5. Discussion of Results

The above investigation shows that the experienced technical listeners capable of assessing critically the technical quality of programmes could not agree on the ranking of a set of different microphone balances. This may be because the subjects, who were consistent as individuals, expressed their preference with respect to different reference standards, for instance, the sounds produced by their own monophonic sound reproducing systems. The subjects who were statistically inconsistent most probably changed their reference standards during the test as suggested in 2.2.

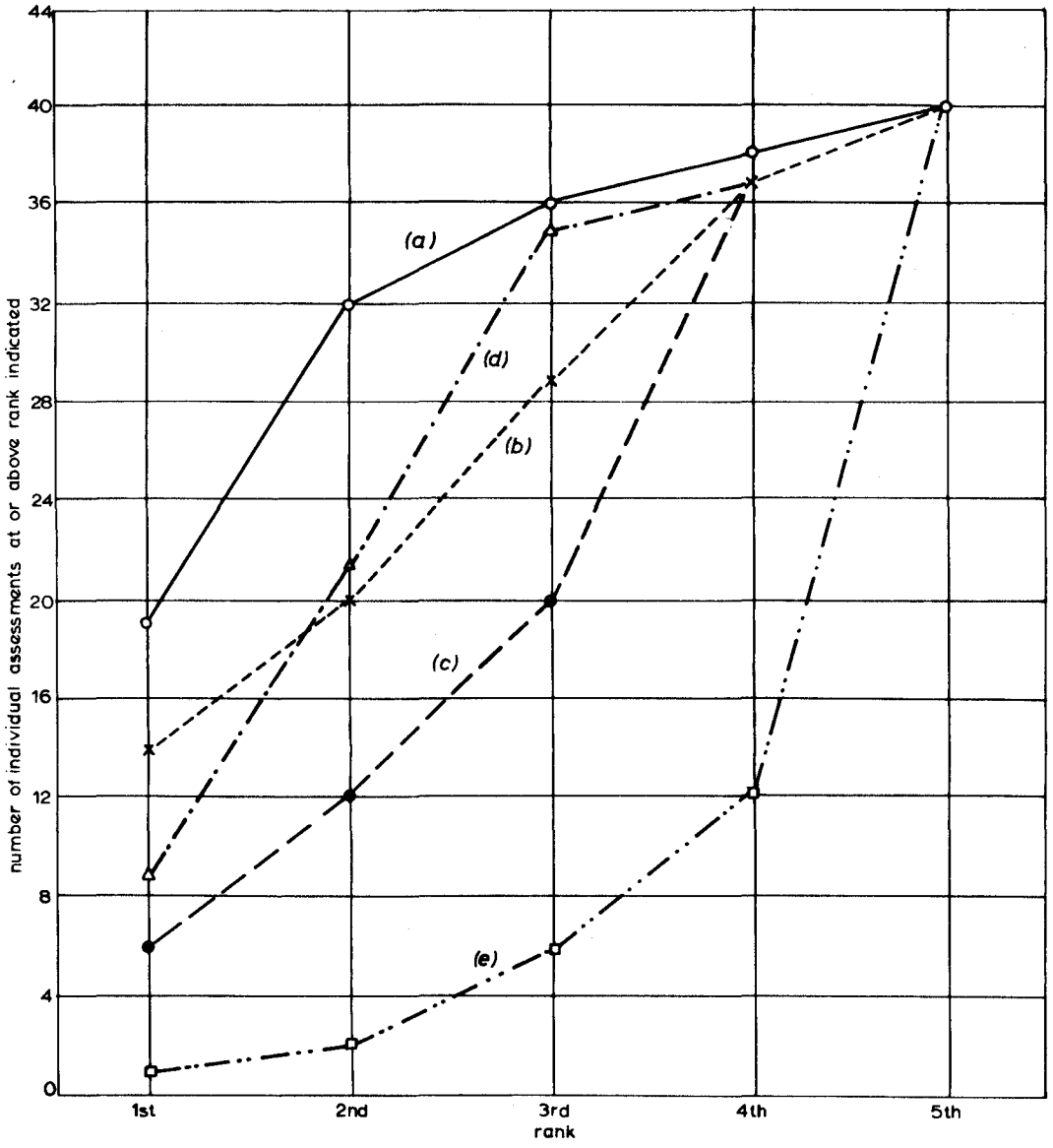

Fig. 9 - Graphical analysis of results for 40 concert-going members of the public. Rank order of areas under the curves: A, D, B, C, E

(*a*) Condition A (*b*) Condition B (*c*) Condition C (*d*) Condition D (*e*) Condition E

Members of the general public who are active concert goers would appear to be more consistent as individuals than the technical listeners, and this suggests that as a group these subjects had a common standard of reference which did not change during the test. This group was able to give a significant group preference order for the five microphone balance conditions.

It should be noted that in the comparison of the conditions C and D all three groups preferred the single main microphone (condition D) of the transmitted balance rather than the complete reinforced balance transmitted (condition C). The group of concert goers had a clear preference for a single microphone balance rather than a reinforced balance and also had a definite preference for a distant single-microphone balance rather than a close single-microphone balance.

3. FINAL INVESTIGATION

3.1. Introduction

As a result of the discussions mentioned in Section 1 above, it was decided to extend the investigation to music of different historical periods and of widely different orchestral texture. Simultaneous recordings were made of short passages from the following compositions:

Bartok:	Concerto for Orchestra
Berlioz:	Symphony Fantastique
Britten:	Variations for string orchestra on a Theme by Frank Bridge
Haydn:	Symphony No. 93 in D

The Haydn and Bartok excerpts were recorded with five different balance conditions similar to those described in Section 2.3.

Conditions A and B were distant single microphone balances

Condition C was the reinforced transmitted balance

Condition D was a close single microphone forming the main part of the Studio Manager's balance.

Condition E was another close single microphone balance.

The transmitted reinforced balance and the single microphone balances were arrived at independently in separate listening rooms by the Studio Manager and the Research Department team respectively. During rehearsals for the Berlioz and Britten recordings, the Studio Manager found it necessary to modify his balance, adding an extra microphone to reinforce the lower strings in the balance for transmission. This incidentally resembled more closely the sounds obtained from the single microphones.

Five test tapes were prepared from the extracts. Two excerpts from the Bartok Concerto for Orchestra were used, together with one excerpt each from the Haydn, Britten and Berlioz compositions. A total of 98 members of the public participated in these tests, and the results obtained are given in Section 3.2.

3.2. Results

In view of the results obtained from the 40 concert goers, as discussed in 2.4 the results in this part of the investigation are analysed only by normal rank correlation methods.

3.2.1. Haydn

A total of 98 subjects participated in this test, of whom 63 were self consistent. Table 6 summarises the results.

TABLE 6

	B	A	C	E	D	Total Preferences	Rank
B	-	58	62	59	79½	258½	1
A	40	-	58	74	61½	233½	2
C	36	40	-	62½	72	210½	3
E	39	24	35½	-	43	141½	4
D	18½	36½	26	55	-	136	5
						980	

From Table 6 it may be seen that the 98 subjects showed a preference for a distant single microphone balance rather than for a reinforced balance. The subjects had a pronounced dislike of a very close microphone balance. Appendix 2.1 gives the statistical analysis of the results tabulated in Table 6 and shows that the results are highly significant.

3.2.2. Bartok, first excerpt

A total of 87 subjects, of whom 62 were self consistent, participated in the tests in this section. Table 7 tabulates the expressed preferences:

TABLE 7

	A	B	C	D	E	Total Preferences	Rank
A	-	54½	48½	73	74½	250½	1
B	32½	-	49½	60	68½	210½	2
C	38½	37½	-	67	62½	205½	3
D	14	27	20	-	50½	111½	4
E	12½	18½	24½	36½	-	92	5
						870	

Again this test indicated that the subjects had a marked preference for the single distant microphone balance and a pronounced dislike for the sound quality produced by close microphones. The statistical analysis summarised in Appendix 2.2 again shows the results to be highly significant.

3.2.3. Bartok, second excerpt

It was found that doubling the number of test subjects did not produce a significant change in the result and it was therefore decided that 50 subjects would be an adequate number to participate in the remaining tests. In this particular test 45 of the 50 subjects were self consistent. Table 8 summarises the preferences expressed.

TABLE 8

	A	C	B	D	E	Total Preferences	Rank
A	-	31	28½	31½	34	125	1
C	19	-	26	32	36½	113½	2
B	21½	24	-	30½	32	108½	3
D	18½	18	19½	-	30½	86½	4
E	16	13½	18	19½	-	67	5

There is a marked group preference for a single distant microphone and a pronounced dislike of close microphones. The statistical analysis in Appendix 2.3 shows that the results are significant.

3.2.4. Britten

In this excerpt 35 of the 50 subjects participating were self-consistent. As mentioned in Section 3.1 the reinforced balance was modified before recording the Britten and Berlioz excerpts. The modification was basically the addition of a separate microphone to reinforce the low strings thereby producing a sound which was much closer to the single microphone output. Microphone condition D was eliminated as the Studio Manager had decided to fade it down with the changed balance leaving four conditions A, B, C and E. Table 9 summarises the results:

TABLE 9

	C	A	B	E	Total Preferences	Rank
C	-	29½	21½	40½	91½	1
A	20½	-	28	41	89½	2
B	28½	22	-	36	86½	3
E	9½	9	14	-	32½	4

The total number of preferences expressed for conditions A, B and C can be seen from Table 9 to differ by very small amounts, suggesting that no marked preference was held by the group for any one of the balances. However, Appendix 2.4 shows that there is a significant coefficient of agreement. Further analysis given in Appendix 2.4 shows that the significance lies in the groups' dislike of the close microphone balance and that the results for the comparisons of conditions A, B and C could well have arisen by chance.

3.2.5. Berlioz

In this test 27 of the 50 subjects were self consistent. Table 10 summarises the results:

TABLE 10

	C	B	A	E	Total Preferences
C	-	27½	30	27½	85
B	22½	-	25	27	74½
A	20	25	-	20	71
E	22½	23	24	-	69½

Appendix 2.5 shows that there is little agreement between observers and the results could have arisen at random.

3.3. Discussion of Results

During informal discussions at the end of each test section the subjects were asked to enumerate as far as possible the factors which governed their final choice of balance condition. The information obtained was that in general the concert goers could quite easily assess the relative merits of the different microphone balances both for classical and contemporary music in passages where the main theme was given to the violins with the remainder of the orchestra providing the accompaniment. This type of passage applies to the Haydn and first Bartok excerpts as well as to the Beethoven passage in the preliminary test. This is not unexpected since the acoustic radiation pattern for violins and viola shows that the high frequency energy is concentrated in a narrow lobe perpendicular to the belly of the instrument, thus the audience in an auditorium hears the somewhat unpleasant bowing noise at considerably reduced amplitudes compared with those of the fundamental and first few harmonics. A microphone suspended over the violin section of an orchestra will pick up sound energy of large amplitude in the high frequency region, thereby producing a harshness and stridency in the string tone which is not normally heard in the concert hall.

In the Berlioz excerpt the theme is given to the full brass and the subjects had great difficulty in expressing a preference for any balance condition. Similarly in the Britten variations, in which each string section is subdivided, it was difficult to assess the relative merits of the different pairs of comparisons. It should again be emphasised that for the Britten and Berlioz excerpts the reinforced balance had been changed and gave a sound more similar to the distant single microphone balances. It was to be expected that the subjects would experience difficulty in assessing the three conditions.

4. CONCLUSIONS

This series of tests has shown that musical members of the public are able, for certain types of music, to assess the relative merits of different microphone balances with a remarkable degree of consistency. It has been demonstrated that for music such as the Haydn, Beethoven and Bartok excerpts a distant single microphone balance is significantly preferred to a reinforced balance. The three balance conditions A, B and C were all adequate for the transmission of symphonic music and the improved string tone obtained with a single distant microphone was the decisive factor in arriving at the final order of preference in the Haydn, Beethoven and Bartok excerpts. It would therefore appear that for transmissions of orchestral music the added complexity of reinforced balance techniques does not in general produce any improvement over a single distant microphone balance, and that in some cases a reinforced balance may be a definite disadvantage.

5. ACKNOWLEDGEMENTS

The author wishes to acknowledge with gratitude the help of those members of the musical public who gave their time to this investigation and particularly members of the following music societies:

1. Wallington, Carshalton and Beddington Music Society
2. Croydon Youth Orchestra
3. Croydon Philharmonic Society
4. Sutton Music Society

6. REFERENCES

1. KENDALL, M.G. 1948. Rank correlation methods. London, Griffin and Co., 1948, p. 121.
2. Op.Cit. p. 123
3. Op.Cit. p. 125.

APPENDIX 1

Suppose that m observers each provide $\binom{n}{2}$ preferences between all possible pairs of n objects. The coefficient of agreement u between pairs of observers can be calculated[1] from

$$u = \frac{2\Sigma}{\binom{m}{2}\binom{n}{2}} \qquad (1)$$

where $\Sigma = \Sigma\binom{\gamma}{2}$, the summation extending over all the $n(n\text{-}1)$ cells in the table of paired comparisons. The significance of the results can be determined[2] by calculating the x^2 distribution for the paired comparison data:

$$x^2 = \frac{4}{m-2}\left\{\Sigma - \tfrac{1}{2}\binom{m}{2}\binom{n}{2}\frac{m-3}{m-2}\right\} \qquad (2)$$

The number of degrees of freedom v is given by

$$v = \binom{n}{2}\frac{m(m-1)}{(m-2)^2} \qquad (3)$$

Knowing v, the significance level P of the result can be obtained from tables[3]. These equations will now be applied to the data in the paired comparison tables obtained during two series of tests.

1.1. Engineers

The results for the 15 engineers are given in Table 1 which is repeated here:

TABLE 1

	A	C	B	D	E	Total Preferences
A	-	10	7	12	9	38
C	5	-	8½	7	9	29½
B	8	6½	-	6½	8	29
D	3	8	8½	-	8	27½
E	6	6	7	7	-	26

Providing that the table is laid out with the objects in rank order the summation $\Sigma\binom{\gamma}{2}$ taken over the $n(n\text{-}1)$ cells in the table can be shown to be given by[4]

$$\Sigma = \Sigma\gamma^2 - m\Sigma\gamma + \binom{m}{2}\binom{n}{2} \qquad (4)$$

where the summation is now restricted to the $n(n\text{-}1)/2$ numbers below the diagonal.

From the data in the table of paired comparisons we have

$$\Sigma = 521{\cdot}5$$

now $n = 5$ and $m = 15$

$$\therefore \quad \binom{n}{2}\binom{m}{2} = 1150$$

Substituting these values in Equation 1 we have

$$u = -0{\cdot}006$$

The negative sign indicates disagreement between pairs of subjects. Substituting for n, m and Σ in Equation 2 we find

$$x^2 = 14{\cdot}9$$

Substituting for n and m in Equation 3

$$v = 12{\cdot}3$$

Hence from the tables $P = 0{\cdot}3$. We conclude that there is a 30% chance that the results could have arisen in random fashion.

1.2. Studio Managers (14 subjects)

Taking the data given in Table 3 and proceeding as in Appendix 1.1 we find

$$u = 0{\cdot}29$$

$$v = 12{\cdot}6$$

$$x^2 = 30{\cdot}6$$

whence $P = 0{\cdot}01$

The result is therefore statistically significant at the 1% level. The significance rests in the dislike of the conditions E and B (the very close and very distant single microphone balances) rather than a preference for any one condition. This can be demonstrated if u, v and x^2 are calculated from the data for the three conditions A, C and D. The result of such calculations gives a negligibly small negative coefficient of agreement and shows that there is a 30% chance that the preferences could have arisen at random.

1.3. 40 Concert Going Members of the Public

The relevant data is given in Table 5. Proceeding as in 1.1 of Appendix 1 we find

$$u = 0{\cdot}246$$

$$v = 10{\cdot}7$$

$$x^2 = 111{\cdot}7$$

whence $P < 0{\cdot}01$

Thus there is a considerable measure of agreement between pairs of subjects and it is highly improbable that the preferences could have been allotted at random.

APPENDIX 2

In this appendix the values of u, v and x^2 are calculated from the results obtained in the final series of five tests.

2.1. Haydn

In this test the relevant data is given in Table 6 from which we calculate, following Appendix 1.1.

$$u = 0{\cdot}11$$

$$v = 10{\cdot}3$$

$$x^2 = 120{\cdot}5$$

whence $P < 0{\cdot}01$

Thus there is a measure of agreement between pairs of subjects and it is most improbable that so high a value of x^2 could have arisen had the preferences been allotted at random.

2.2. Bartok, first excerpt

Calculations on the data in Table 7 give the following results

$$u = 0{\cdot}195$$

$$x^2 = 182$$

$$v = 10{\cdot}37$$

$$P = <<0{\cdot}01$$

The coefficient of agreement of 0·195 between pairs of subjects indicates a measure of agreement. The value of P shows that so high a value of x^2 could not have arisen had the preferences been allotted at random.

2.3. Bartok, second excerpt

The coefficient of agreement and its significance for this test are calculated from Table 8. We find:

$$u = 0{\cdot}05$$

$$x^2 = 38{\cdot}8$$

$$v = 10{\cdot}64$$

$$P = <0{\cdot}01$$

Thus there is a very slight measure of agreement between pairs of observers but it is improbable that the preferences were allotted at random.

2.4. Britten

The results of this test are given in Table 9 from which it will be seen that the total number of preferences allotted to conditions A, B and C do not differ greatly.

The coefficient of agreement is calculated to be:

$$u = 0{\cdot}195$$

$$x^2 = 55$$

$$v = 6{\cdot}3$$

$$P = <0{\cdot}01$$

Thus there is a certain amount of agreement between pairs of observers, and it is improbable[3] that the result could have arisen at random.

That the significance of the result lies in a general dislike of condition E may be demonstrated by recalculating u, x^2 and v from the data relevant to the three conditions A, B and C.

We find in this case

$$u = 0{\cdot}0002$$

$$x^2 = 3{\cdot}6$$

$$v = 3{\cdot}18$$

$$P = 0{\cdot}4$$

Thus there is negligible agreement between pairs of subjects; from the significance tables[3] we find that there is a probability of 40% that these preferences could have been allotted at random.

2.5. Berlioz

The data in Table 10 gives, on analysis, the following results:

$$u = -0{\cdot}009$$

$$x^2 = 3{\cdot}65$$

$$v = 6{\cdot}3$$

$$P = 0{\cdot}8$$

and thus there is no measurable agreement between pairs of subjects, and there is an 80% chance[3] that the results could have arisen at random.

3. REFERENCES

1. KENDALL, M.G. 1948. Rank correlation methods. London, Griffin and Co., 1948, p. 125.

2. Op.Cit. p. 129.

3. Op.Cit. Table 8, p. 153.

4. Op.Cit. p. 127.

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